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Use of calliandra–Napier grass contour hedges to control erosion in central Kenya

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Abstract

Contour hedgerow systems consisting of various combinations of tree and grass species can be used on sloping lands to minimize erosion, restore fertility, and improve crop productivity, but there is need to evaluate the effectiveness of each system for its suitability at any locality as effective erosion control. The objectives of this study were to determine the amount of soil conserved by contour calliandra (*Calliandra calothyrsus*)–Napier grass (*Pennisetum purpureum*) hedgerows, and then develop a support practice P-subfactor for conservation planning in central Kenya. As a benefit beyond soil conservation, biomass yield and N and P retention by the hedgerows were determined. Cumulative data for five cropping seasons from 1997 to 1999 indicated that the contour hedges on 20% slope conserved more soil (168 Mg ha^{-1}) than on the 40% slope (146 Mg ha^{-1}) compared to the control plots. For both slopes, this was equivalent to a 0.7 P-subfactor for use by the Revised Universal Soil Loss Equation (RUSLE) model in predicting soil erosion. The N and P losses between the hedges and control were statistically significant only on the 20% slope ($P = 0.05$). Combined biomass yield from the calliandra–Napier grass hedges were 12 and 9 Mg ha^{-1} per year and 40% slopes, respectively. This soil conservation technology may be used by small-scale farmers that use mixed farming systems in the highlands of central Kenya and similar ecoregions as a step towards sustainable farming.
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1. Introduction

Soil erosion by water is a global problem and more so in the tropical regions due to the torrential nature of rainfall and highly erodible soils. While several methods exist for control of water erosion, the use of tree hedges (hedgerows) on contours of steep slopes has become increasingly important (Young, 1989, 1997; Angima et al., 2000). Success in the use of hedgerows has been observed in Nigeria, Columbia, and Kenya where 48–85% reduction in soil loss has been observed (Young, 1989; Kiepe and Young, 1992, 1997; Angima et al., 2000). Trees in hedgerow systems can serve as soil erosion barriers and nutrient retention enhancers through their influence on the supply and availability of nutrients in the soil through biological N_2 fixation, retrieval of nutrients from below the rooting zone of

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crops, and reduction in nutrient losses from leaching and erosion such as P and N. The ability of trees to enhance nutrient availability is greater on soils with high base saturation than those with low base saturation (Szott et al., 1991).

One tree species used in agroforestry systems that has had remarkable success in conserving soil, nutrient cycling, and nutrient retention is calliandra (*Calliandra calothyrsus*). Calliandra, indigenous to central America, is a small tree that reaches about 10 m in height and grows naturally in moist, tropical regions up to an altitude of 1500 m (Paterson, 1994). Calliandra can improve soil quality and increase yields of associated crops and grass species such as Napier grass (*Pennisetum purpureum*) (National Research Council, 1983; Nitrogen Fixing Trees Association, 1988; Goudreddy, 1992). Napier grass is a tall perennial grass reaching over 3 m high, resistant to drought, and grows at altitudes up to 2400 m with a minimum rainfall of 900 mm (Henderson and Preston, 1959). Biomass yields from Napier grass range between 12–150 Mg ha^{-1} per year depending on fertility, management, and the variety of Napier grass used (Henderson and Preston, 1959; Purseglove, 1985; Orodho et al., 1992). The effectiveness of combinations of calliandra with Napier grass used in hedges for erosion control is thought to be due to the stem strength of the calliandra and the massive near-surface lateral root system of the Napier grass.

Data from soil erosion studies can be used in soil erosion prediction models including the Revised Universal Soil Loss Equation (RUSLE) developed and used for conservation planning in the USA (Renard et al., 1997) and that has been used in many countries. The use of RUSLE, however, requires site-specific parameters that adequately address the erosion hazard specific to the locality. RUSLE computes the average annual erosion expected on field slopes by multiplying the rainfall and runoff erosivity R-factor, soil erodibility K-factor, slope length and steepness LS-factor, cover and management practices C-factor, and support practice P-factor (Foster et al., 1977; Renard et al., 1997). On croplands, support practices include contouring (tillage and planting on or near the contour), strip cropping, terracing, and subsurface drainage (Renard et al., 1997). The support practice P-factor is affected most by management practices carried out by landowners. Thus, it is important that local management practices be considered in the development of the sub-factor, so that conservation planning will reflect local conditions.

This research was conducted in the Kianjuki catchment area located in the Embu District of central Kenya, which is within the research mandate region of the Kenya Agricultural Research Institute (KARI) working collaboratively with the International Center for Research in Agroforestry (ICRAF). Objectives for this study were to: (1) determine erosion rates from on-farm plots with and without contour calliandra–Napier grass hedges; (2) use the soil loss data to develop a support practice P-subfactor for use with the RUSLE soil erosion prediction computer model; (3) determine biomass production from the hedges; and (4) determine N and P losses in eroded sediments from the runoff plots to gauge the effectiveness of the combination hedge system in retaining nutrients. The study had the following hypotheses: (1) the calliandra–Napier grass hedges, when used as contour hedgerows, will significantly reduce soil loss; (2) the support practice P-subfactor for calliandra–Napier grass hedges will be less than the support P-subfactor for terracing found in the RUSLE database; (3) the combined biomass yields from the calliandra–Napier grass hedges will be lower on steeper slopes as a result of soil and nutrient losses; and (4) losses of N and P with the eroded sediments from plots with calliandra–Napier grass hedges will be significantly less than the control.

2. Methods

2.1. Study site

The study site was located in the Kianjuki catchment area in the Embu District of central Kenya. The climate of this area is representative of the east African highlands. The catchment lies on latitude, 00°30′S, longitude, 37°27′E and an altitude of 1480 m above sea level (Angima et al., 2000; O'Neill et al., 1993). Average annual rainfall is 1500 mm, which comes in two seasons referred to as the long rains (March–September) and the short rains (October–February). This catchment, or watershed, is a primary water source for the Tana River, which is used for hydroelectric power generation that feeds into the general electric grid for eastern Kenya and eventually flows into the Indian Ocean.

2.2. Experimental design

This study was carried out on-farm with local farming practices. Data were collected from 12 runoff plots measuring 2.5 m by 9 m laid out at specific sites in the catchment. Six of the plots were on 20% slope that was located on the shoulder of the hillslope and the other 6 on 40% slope that lay on backslope of the hillslope. There were two treatments with three replications on each slope in a randomized complete block design. The treatments were (a) calliandra–Napier grass hedge across the bottom of the plot that consisted of one row of calliandra and one row of Napier grass, and (b) control plots with no hedge. Spacing within the hedgerows were 50 cm for Napier grass and 25 cm for calliandra. Spacing between the Napier grass row and calliandra row were 75 cm. The calliandra row preceded the Napier grass row upslope of the hedge to reduce the competition between calliandra and the adjacent crops. Calliandra was inoculated with *Rhizobium* spp. before planting in order to ensure nodulation with an effective strain, enhancing the nitrogen fixing capability of the legume. Maize (*Zea mays* L.) was grown on all plots seeded at the rate of 53,000 plants ha^{-1}, which is the rate used by local farmers.

2.3. Soils

The soils in the catchment are classified as Humic Nitisols (FAO, 1990) and have a soil reformation rate of 2.2–4.5 $Mg\,ha^{-1}$ per year for the top 0–25 cm of the soil and 4.5–10 $Mg\,ha^{-1}$ per year for the 25–50 cm layer (McCormack and Young, 1981; Kilewe, 1987). Soil samples from the Kianjuki catchment were collected from several random spots on the plots and bulked and a composite sample was drawn. For eroded sediments, all samples were air-dried, weighed, and then bulked. A composite sample was drawn for analysis. The pH of the sample was determined using a slurry of 2:1 water to air-dried soil (Table 1). Infiltration rates were determined by double-ring infiltrometer method (Jury et al., 1991). Total carbon was determined by dry combustion (CHN-600, Leco Corp., St. Joseph, MI). Percentages of clay and silt, and the particle size distribution were determined by the pipette method (Gee and Bauder, 1986). Percent organic carbon that was associated with the clay fraction (organic-clay complexes) was determined by the dry combustion method. The percentage of sand and gravel were determined by wet sieving (Gee and Bauder, 1986). The material remaining in the sieves was crushed with a rubber policeman under running water to separate the sand, and then oven dried at 105 °C for 24 h. The sand was then passed though a vibrating nest of sieves that separated the sand into five fractions: very coarse (1–2 mm), coarse (0.5–1 mm), medium (0.25–0.5 mm), fine (0.10–0.5 mm), and very fine (0.05–0.1 mm).

2.4. Runoff and erosion

The boundaries of each plot were defined by galvanized steel sheets 50 cm high and inserted up to 20 cm below the soil surface to prevent water and soil from leaving or entering the plot. Runoff and soil loss were collected at the base of each plot in 400 L drums. Samples were drawn from the runoff to determine total soil loss for each rainstorm. A rain gauge close to the plots provided data for total rainfall amounts.

Table 1
Soil chemical and physical properties for the treatment plots in the Kianjuki catchment of central Kenya

Slope treatment	Clay ($g\,kg^{-1}$)	Silt ($g\,kg^{-1}$)	Sand ($g\,kg^{-1}$)	pH	Organic-clay complexes		Organic C ($g\,kg^{-1}$)	Infiltration rates ($mm\,h^{-1}$)
					Inside plot ($g\,kg^{-1}$)	Eroded sediments ($g\,kg^{-1}$)		
20% Control	689 a[a]	184 d	127 d	4.7 b	21.0 a	15.0 a	11.3 a	900 a
20% Hedge	639 b	204 c	157 c	5.1 a	20.9 a	14.8 a	12.9 a	720 a
40% Control	532 d	288 a	180 a	4.6 b	20.6 a	14.1 a	11.8 a	880 a
40% Hedge	549 c	277 b	173 b	4.9 ab	20.8 a	14.7 a	12.2 a	900 a

[a] If the same letter appears within-column, differences are not significant at the 5% level by Duncan's multiple range test.

2.5. Support practice P-subfactor for calliandra–Napier grass hedge

Computation of the support practice P-subfactor (P) for the calliandra–Napier grass hedges was based on the procedure for determining subfactors for soil conservation strips in RUSLE version 1.06 (Renard and Foster, 1983; Renard et al., 1997), and is as follows:

$$P = \frac{g_{\mathrm{p}} - B}{g_{\mathrm{p}}} \quad (1)$$

where P is the value of support practice P-subfactor for the calliandra–Napier grass hedge, g_{p} the sediment load in the runoff at end of control plots (i.e. total soil collected from runoff), and B is the amount of deposition considered to benefit the long-term maintenance of the soil resource. The value for g_{p} is calculated as

$$g_{\mathrm{p}} = \sum_{i=1}^{n} D_{ni} \quad (2)$$

where D_{ni} is the net erosion on the control runoff plot, n the number of conservation hedges, and i is the subscript indicating a particular hedge. The value for B in Eq. (1) is calculated as

$$B = \sum_{i=1}^{n} M_i (1 - x_{i-1}^{1.5}) \quad (3)$$

where x is the relative distance from the top of the slope to the lower edge of the hedge, i.e. absolute distance divided by the slope length, and M is the amount of deposition, i.e. difference between the sediment lost from the control plot and the sediment lost from the treatment.

2.6. Biomass yield

Napier grass and calliandra were harvested twice each growing season. The cutting height for the Napier grass was 10 cm above the ground while the cutting height for calliandra was 50 cm. The leaves and stems of calliandra were separated, dried, and weighed to determine total biomass yield for each cutting. In this study, the slopes were not replicated.

2.7. Analysis of P and N

Total concentrations of P and N were determined for the soil sediments that had been eroded and collected in the drums. Total P was measured colorimetrically after digesting the sample with perchloric acid and fusion with ammonium molybdate (Olsen and Sommers, 1982). Total N was determined by dry combustion (CHN-600, Leco Corp., St. Joseph, MI).

2.8. Statistical analysis

A randomized complete block design was used for this experiment. Analysis of variance (ANOVA) was determined for the runoff and soil loss data using the SAS version 6.12 (SAS Institute, 1996). Unless otherwise stated, differences are statistically significant at $P < 0.05$.

3. Results and discussion

3.1. Soils, runoff and erosion

Soil properties for the Kianjuki catchment are presented in Table 1. The amounts of clay, silt, and sand on the two slopes varied significantly under each treatment at the conclusion of the study. However, organic-clay complexes, organic carbon, and infiltration rates were not significantly different between treatments (Table 1).

Total annual rainfall for the study years 1997, 1998, and 1999 were 1898, 1296, and 590 mm, respectively. There was a drought in 1999, accompanied by crop failures. Runoff and soil loss from plots with hedges was 30% less than the control plots for the two slopes. There were significant differences between the control and hedge treatments on both slopes for both runoff and soil loss amounts (Table 2). The ratio of soil loss from control plots versus the plots with the hedges was the same (1:0.7) for both slopes. Runoff and soil loss were further characterized according to the total amount of rainfall for each storm (Table 3). The storms were categorized at intervals of 10 mm and average rates of runoff and soil loss calculated depending on the frequency of storms in each category. Storms less than 1 mm were ignored. There was more soil loss from the hedge treatment on the 20% slope for the lowest rainfall categories (1–9, 10–19, 20–29, 30–39 mm), than from the hedge treatment on the 40% slope. This trend for soil loss changed when the rainfall exceeded 40 mm where soil loss was nearly equal or more from

Table 2
Runoff and soil loss rates for three years (1997–1999) at the Kianjuki catchment of central Kenya

Treatment	Runoff (mm per year)			Soil loss (Mg ha^{-1} per year)			20% Slope (cumulative)		40% Slope (cumulative)	
	1997	1998	1999	1997	1998	1999	Runoff (mm)	Soil loss (Mg ha^{-1})	Runoff (mm)	Soil loss (Mg ha^{-1})
Control	346	167	65	434	502	181	356 a[a]	578 a	222 a	529 a
Hedge	307	137	40	336	380	88	298 b	410 b	186 b	393 b

[a] If the same letter appears within-column, differences are not significant at the 5% level by Duncan's multiple range test.

the hedge treatments on the 40% slope than the 20% slope except for the rainfall category 50–59 mm. The same trend for soil loss was observed on the control treatments except for the rainfall category 70–79 mm where soil loss was higher on the 20% slope than the 40% slope.

Surprisingly, the steeper slope did not consistently have the greatest amounts of soil erosion. This could be due to variations in soil properties between all the treatments for the two slopes (Table 1). The treatments on the 20% slope had significantly higher amounts of clay and significantly less sand than those on the 40% slope. Higher clay contents in a soil leads to faster initial surface sealing which results to more runoff (Morgan, 1995). The 40% slope had significantly more silt and sand than the 20% slope, which leads to more erosion at higher rainfall amounts of high intensities on steeper slopes (Morgan, 1995). Organic C and organic-clay complexes in the soils were very low and did not significantly differ between any of the treatments and, therefore, did not play a big role in the erosion process nor were they responsible for differences seen between slopes (Table 2). The slope aspect also contributed to the observed differences in runoff amounts as more raindrops fell on the 20% slope than the 40% slope as a result of the slope angle coupled with the direction of winds during rainstorms that were dominantly blowing parallel to the slopes where the runoff plots were established within the catchment.

There have been other studies using hedges to control erosion. Stiff hedges of the grass *Miscanthus sinesis* were used in Mississippi, USA, reducing soil loss by 67% on conventionally tilled cotton and 38% on no-till cotton over seven years (McGregor, 1998). Terrace formation on the *M. sinesis* grass hedges ranged between 8 and 15 cm high (Ritchie et al., 1997). Flume studies have shown that narrow hedges of tall, stiff grasses across locations of concentrated overland flow

Table 3
Characterization of average runoff and soil loss for a range of rainfall amounts from plots with or without calliandra–Napier grass hedges for two different slopes[a]

Rainfall (mm)	Storm frequency	Total storms (%)	Runoff (mm)				Soil loss (Mg ha^{-1})			
			20% slope hedge	40% slope hedge	20% slope control	40% slope control	20% slope hedge	40% slope hedge	20% slope control	40% slope control
1–9	3	5	1.3	0.9	1.6	1.8	1.0	0.7	1.1	0.7
10–19	14	24	2.1	1.9	3.6	3.2	1.8	1.5	3.0	2.6
20–29	12	20	2.7	1.7	4.7	2.9	3.5	2.7	4.6	2.8
30–39	5	8	3.6	2.5	4.8	3.2	3.7	4.6	5.9	5.7
40–49	9	15	9.9	6.5	11.9	7.6	14.4	16.4	18.3	18.7
50–59	6	10	9.6	5.6	13.2	7.8	10.0	4.2	10.4	8.9
60–69	3	5	16.1	12.3	16.9	16.0	7.6	7.5	10.5	12.5
70–79	2	3	14.9	10.1	17.5	9.4	20.6	25.9	28.5	20.9
<80	5	8	6.7	3.9	6.9	4.7	9.4	9.3	14.3	16.7
Total	59	100								

[a] Measurements were made during 5 cropping seasons (1997–1999) at the Kianjuki catchment in central Kenya. Storms with less than 1 mm rainfall were ignored.

have great potential for retarding runoff and reducing sediment losses. Hedges of switchgrass (*Panicum virgatum*) and vetiver grass (*Vetiveria zizanioides*) caused backwater depths of up to 400 mm and trapped more than 90% of the sediment that was lost from the control treatments without hedges (Meyer et al., 1995). It is evident that hedges can act as good barriers to erosion and there is need to use species that are well adapted to each locality.

3.2. Support practice P-subfactor for calliandra–Napier grass hedge

The total sediment load (g_p, Eq. (2)) during the study (five rainy seasons) for the control plots averaged 578 Mg ha^{-1} for the 20% slope and 539 Mg ha^{-1} for the 40% slope (Table 2). For the same period, soil deposition (B, Eq. (3)) due to the hedges was 168 Mg ha^{-1} on the 20% slope and 146 Mg ha^{-1} on the 40% slope. This translates to a P-subfactor of 0.71 for the 20% slope and 0.73 for the 40% slope for the calliandra–Napier grass hedges (0 is best soil conservation and 1 is no soil conserved). Runoff through the calliandra–Napier hedge is retarded enough to allow soil deposition upslope of the hedge, therefore, gradually forming a terrace and allowing less water to move through the hedge with significantly less erosive force that does not erode soil down slope of the hedge. This phenomenon is important because then, the P-subfactor for the hedges is considered to have more benefit as it relates to both terrace-type and strip-type P-subfactor compared to only strip (hedge) P-subfactor. This is because less benefit is given to strips than terrace-type practices in calculating overall P-factor in RUSLE. This P-subfactor compares well with RUSLE subfactor for terracing which ranges between 0.6 and 1.0 depending on whether the terrace ends in an open or closed outlet with varying grades (Renard et al., 1997).

In Kabale, Uganda, calliandra hedges at the same plant-to-plant spacing as in this study were used on a 40% slope. After 5 years, a support practice subfactor ranging between 0.2 and 0.7 was realized, depending on the inter-row spacing used between the hedges. For an interrow spacing of 2 m, the P-subfactor value was 0.7. For a 4 m inter-row spacing the P-subfactor value was 0.2, while with the 6 m interrow spacing, the P-subfactor value was 0.4 (Personal Communication, Dr. Thomas Raussen). This showed that the closer or further the hedges were from 4 m, the higher the support practice P-subfactor. More erosion and runoff from interrow spacings closer than 4 m may be due to the combined effect of raindrops accumulating on the leaves of the calliandra canopy, and increasing in size before dropping off the leaf edge, resulting in a greater degree of soil detachment per unit area. Closer spacing may generate results closer to forestry conditions, however, the ground was bare for crop cultivation. The present study simulated an interrow spacing of 9 m, with the upper edge of the plot boundaries serving as a barrier to erosion from the upslope area, resulting in a P-subfactor of 0.7 for the local soil and crop management systems. Differences in soil type, climate, rainfall, rainfall intensities and management are contributing factors to differences in the effectiveness of the hedges in controlling erosion.

The P-subfactor value of 0.7 obtained in this study for the calliandra–Napier grass hedge is less than the P-subfactor for horizontal terraces of less than 34 m with a percent grade greater than 0.8%, which usually have a P-subfactor value of 1 (Renard et al., 1997). However, it is comparable to meadow buffer strips that have a support practice P-subfactor between 0.67 and 0.75 (Renard et al., 1997). The practice of using tree–grass hedges can, therefore, significantly reduce runoff and soil loss, and be considered as another alternative for conservation planning.

3.3. Biomass yield

Combined dry matter yield from the hedges, measured as 11 contour rows of combined hedges of calliandra–Napier grass per hectare, produced an annual mean of 12 Mg ha^{-1} on the 20% slope and 9 Mg ha^{-1} for the 40% slope (Table 4). The 11 contour rows were calculated assuming the distance between successive rows of hedges to be 9 m that was used in the runoff plots. Before the start of the erosion study, these hedgerows of calliandra–Napier grass produced 9 Mg ha^{-1} (Angima et al., 2000). Biomass production is considered an added benefit to maintaining the hedges for erosion and runoff control.

The hedgerow system is especially attractive to farmers who practice mixed farming agriculture. The large tonnage of biomass yield from using hedges as a soil conservation resource can supplement, and

Table 4
Biomass yields from the calliandra–Napier grass hedge, based on 11 contour rows of combined hedge per hectare, from the Kianjuki catchment in central Kenya[a]

Slope	Season	Seasonal biomass production ($Mg\,ha^{-1}$)	Biomass separates (%)					
			Calliandra leaves	S.D.	Calliandra stems	S.D.	Napier grass	S.D.
20%	1998LR[b]	5.33	12	2.5	19	3.0	69	2.3
	1998SR[c]	6.58	26	3.7	22	2.3	52	3.3
	1999LR[b]	5.45	40	1.1	31	2.1	29	2.5
40%	1998LR[b]	3.85	18	2.6	15	0.7	67	3.1
	1998SR[c]	4.31	40	3.8	33	1.5	27	2.4
	1999LR[b]	5.25	44	6.9	39	2.5	17	4.1

[a] The data represent three crop growing seasons over one and one-half years. The slopes were not replicated.
[b] LR: long rains season (March–September).
[c] SR: short rains season (October–February).

in some cases substitute for inputs of protein rations for the animals. Calliandra provides up to 24% crude protein and Napier grass supplies roughage and carbohydrates required by animals for a sustainable animal husbandry enterprise (Blaser et al., 1942; Paterson, 1994). If the cut and carry method is used, then returns to soil in the form of manure can replenish nutrients used up by the hedges. Calliandra is a deep rooted tree which means that leached nutrients can be taken up by roots into the foliage and later returned to the soil if the farmer uses the biomass as mulch or fodder (Jama et al., 1998). Calliandra stems can also be used as fuel wood or stakes for fruit and vegetable gardening.

3.4. N and P losses

Substantial amounts of N and P were measured in the eroded sediments. There were significant differences between treatments on total concentrations of N and P in eroded sediments from the 20% slope, but not from the 40% slope (Table 5). Since N and P concentrations were measured only in eroded sediments and not in runoff water, more cumulative soil conserved by the hedges on the 20% slope could explain the significant differences observed in nutrient retention.

Contour hedgerows promote infiltration on the hedge thereby reducing runoff and soil erosion (Agus et al., 1998). Increased infiltration increases the near vertical leaching of mobile chemicals such as N in the immediate vicinity of the hedges. However, since hedges usually have trees with deep rooting systems, the leached nitrogen is taken up by the roots and transferred within the tree to foliage. Thus, if leaves are returned to the soil, N and P are released for crop growth during the decomposition of the leaves (Jama et al., 1998). Fast-growing trees with high root densities can rapidly reduce subsoil NO_3^- concentrations (Jama et al., 1998). Calliandra and *Sesbania* spp. were found to reduce soil NO_3^- in the top 2 m from 150 to 200 $kg\,N\,ha^{-1}$ within 11 months after establishment in western Kenya. Although, calliandra has been recommended for general soil fertility replenishment, it has been shown to be too competitive (Heinemann, 1997; Mugendi, 1999).

While trees can help retain and cycle N in the soil for sustainable agriculture because of the rapid mobility of the aqueous forms of N, they do not aid in P retention, which has aqueous forms with low mobility. There is a need therefore for soil conservation systems that will enhance retention of P in the soil. Since, combined contour hedges control erosion, they also reduce the loss of P from eroding sediments and

Table 5
Mean total N and P losses in eroded sediments from the Kianjuki catchment in central Kenya

Treatment	P ($Mg\,ha^{-1}$ per year)		N ($Mg\,ha^{-1}$ per year)	
	20% Slope	40% Slope	20% Slope	40% Slope
Control	1.6 a[a]	2.0 a	1.5 a	1.8 a
Hedge	0.9 b	1.4 a	1.0 b	1.4 a

[a] If same letter appears within-column, differences are not significant as determined by Duncan's multiple range test ($P = 0.05$).

runoff. This makes the hedge system a worthwhile investment for the farmer in terms of productivity as well as erosion control.

4. Conclusions

The calliandra–Napier grass hedge significantly reduced both runoff and soil loss. A support practice P-subfactor of 0.7 was calculated for this hedge system for use with the RUSLE erosion prediction model. This P-subfactor value is less than the default RUSLE subfactor value for terracing but comparable to the value for meadow buffer strips. The P-subfactor for this hedge system can be used in RUSLE for conservation planning in the humid and sub-humid tropics.

The added benefit of biomass production and N and P retention by this hedge system, especially on slopes of 20% or less, makes the practice more adoptable and practical compared to earthen structures used for soil conservation. The calliandra–Napier grass hedge system can, therefore, be recommended for small-scale farmers in the central highlands of Kenya and similar tropical regions, especially those that practice mixed farming agriculture and can make use of the nutritive biomass produced by the hedges.

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